Determination of 3D Geometry and Sources of Coronal Streamers using LASCO Data

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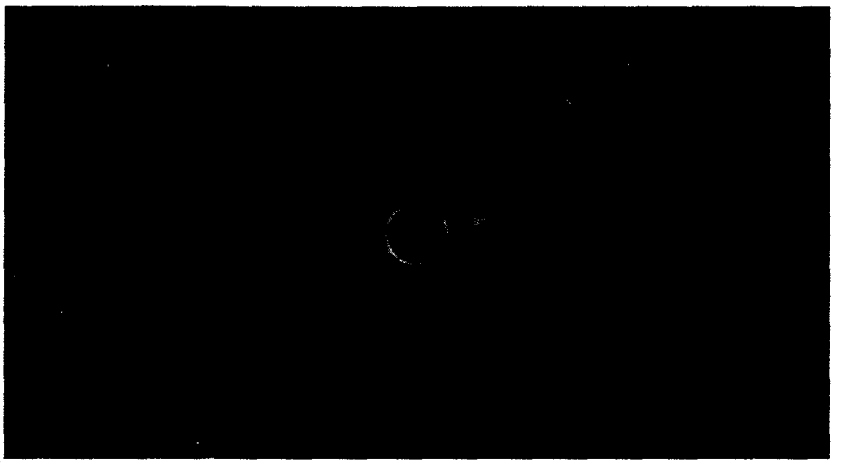


Motivation: What are beam-like coronal streamers?
Helmet streamer stalks? Regions of enhanced density outflow?
Line-of-sight viewing of folds in the current sheet?

Summary of Results

What are beam-like coronal streamers?

- Determine 3D location of LASCO streamers using variation in plane-of-sky angle of streamer with solar rotation
- Compare streamer location to current sheet
- Results for CR1935 (~April 1998)

  All 8 streamers lie in or near the current sheet as expected

  Not all are at current sheet folds ala *Wang et al , Ap J 1997*

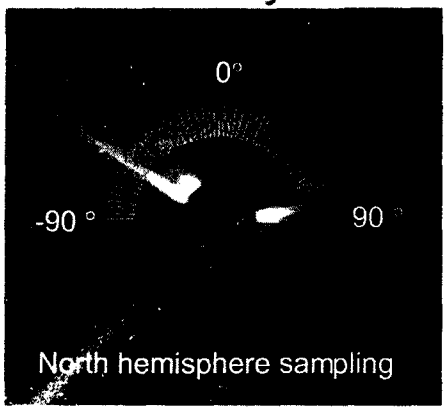
- Determine solar source by mapping from source surface to photosphere along streamer magnetic field line using SS magnetic field model

  6 features map to active regions suggesting streamers are regions of enhanced density and outflow associated with solar activity as suggested by *Wang et al, GRL, 2000*

- Preliminary Results for CR1958 (~January 1999

  6 streamers located, but streamer origin & current sheet location uncertain!

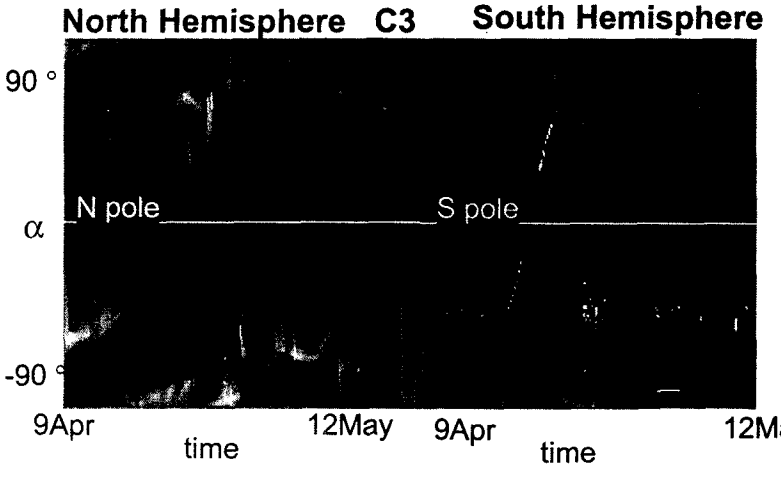
Analysis Procedure for LASCO Images



1. Sample C2 or C3 data in 1 degree increments with user-set radius range
- shown is C3 with range 9<R/R_S<12

North and South hemisphere sampled separately
(Not East&West limbs as in LASCO Carrington plots)

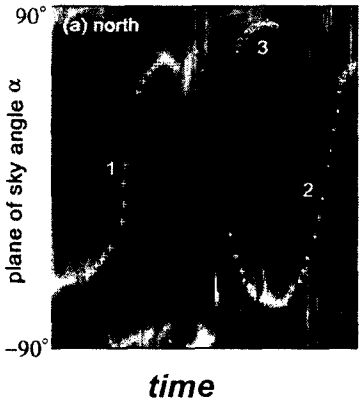
CR 1935:
Data every ~6 hr from April 9-May 12, 1998



2. Plot sampled intensity at each angle α versus time for each hemisphere

3. Place points on features traces with mouse to obtain angle versus time

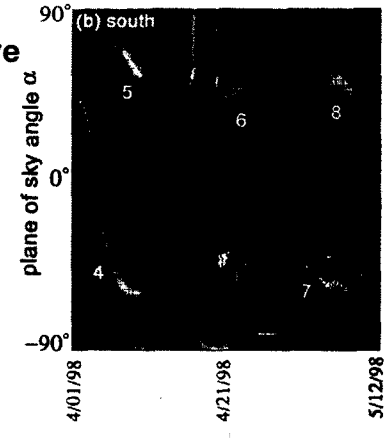
Procedure to Determine Latitude and Longitude



Data points for 6 C2 Active Region Steamers

North hemisphere features

South hemisphere features

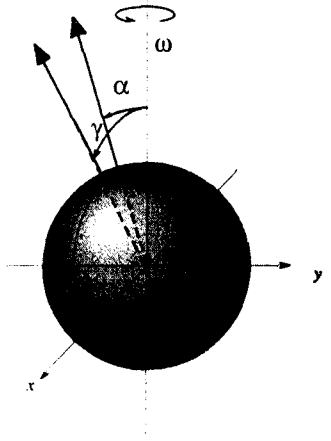


angle in solar coordinates = γ
plane of sky angle (varies in time) = α(t)

Relationship between angles:

$\tan\alpha=\tan\gamma\cos(\phi+\omega\tau)$

ϕ solar longitude of feature
ω coronal rotation rate (use 27 day period)
$\tau=t-t0$ time relative to start of CR1935

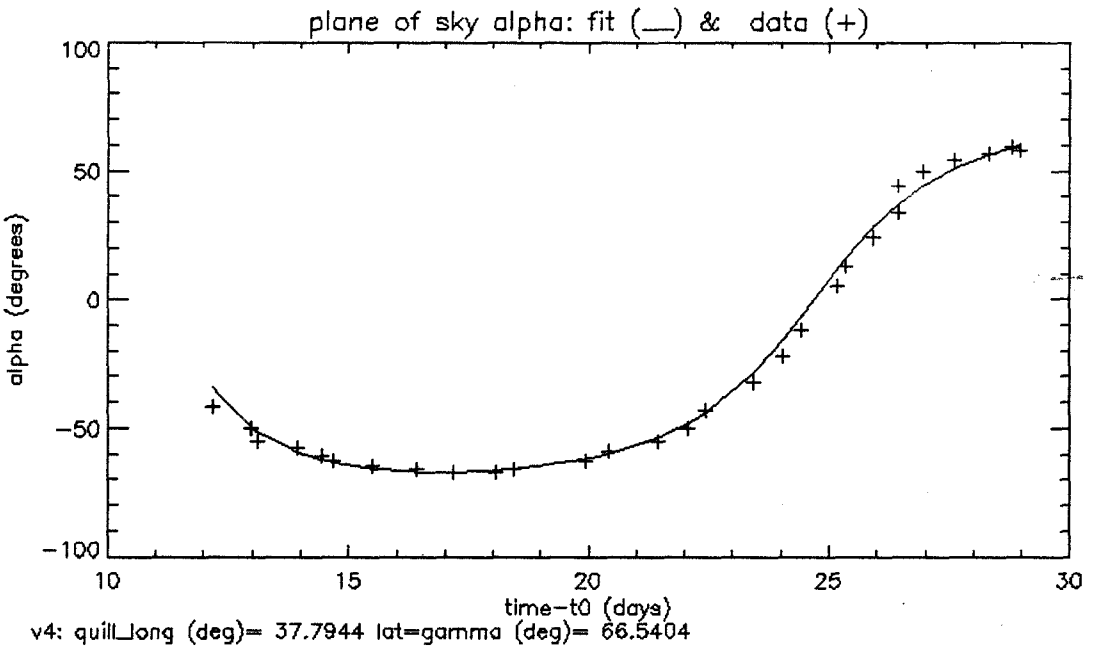


Determine γ,ϕ by fitting curve to traced points

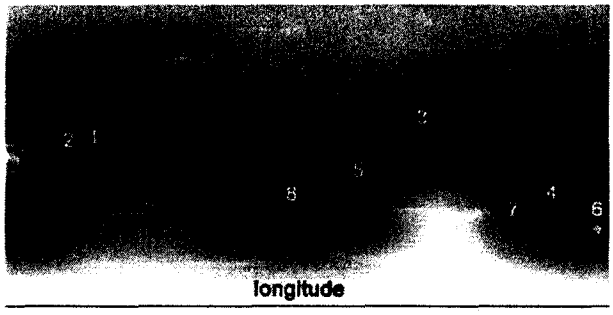
Analysis can also allows a vertical offeset h from Sun center

Sample Fit of Points to Curve

$\tan\alpha(t)=\tan\gamma\cos(\phi+\omega\tau)$

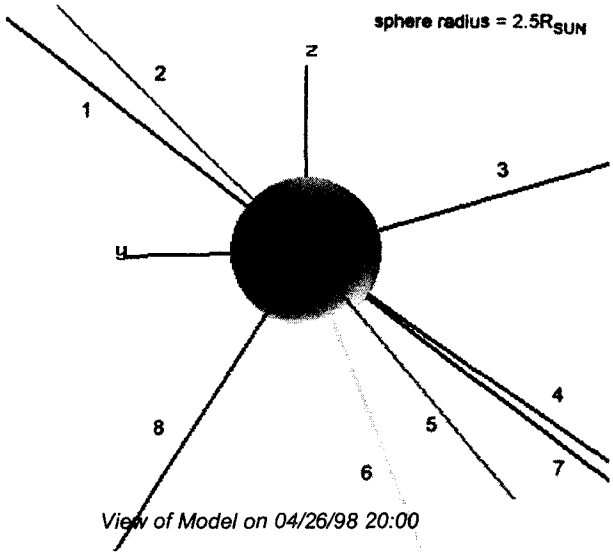


CR1935: All Streamers Located at Current Sheet



Left: CR1935 source surface map showing current sheet

Latitude and longitude of 8 streamers determined (colored dots on CR plots)



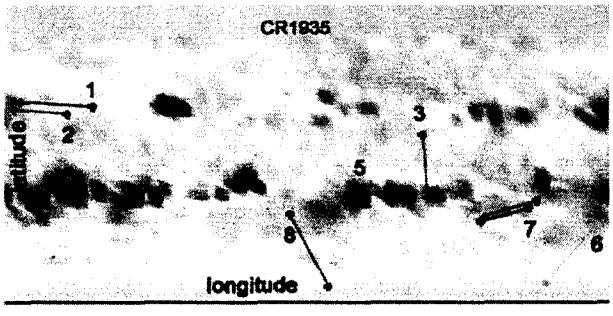
View of Model on 04/26/98 20:00

Compared to current sheet at source surface ($2.5R_S$)

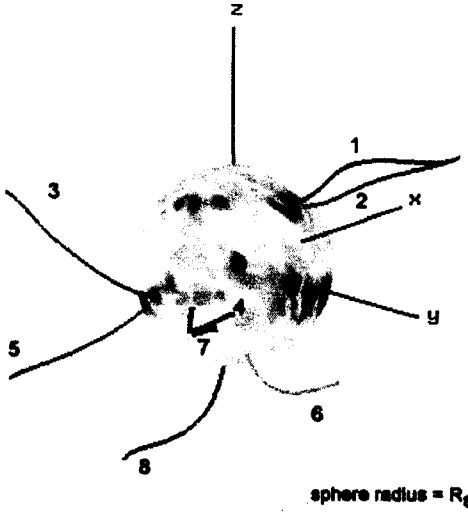
See also Koomen, Howard and Michels, SP, 1998 and refs therein

Next, assume streamers coincide with magnetic field lines and trace from source surface to photosphere

CR1935: 6 of 8 streamers map to active regions



Streamers mapped from source surface to photosphere using potential-source surface magnetic model



Streamers 1-5 & 7 map to active regions

Streamer 8 maps to south coronal hole
Streamer 6 uncertain - here, SCH 6&8 are at folds in current sheet

Hypothesis:
The 6 AR streamers results from enhanced density & outflow associated with activity in AR

How Robust are the mappings?

- Results are insensitive to radial sampling and curve tracing

  Repeated location determine using different radial samplings

  No significant changes in mapping of location to photosphere

- Results are insensitive to magnetic model parameters

  No significant changes in mapping of location to photosphere

- Results depend strongly on photospheric boundary conditions

  Map above for CR1935- some steamers in CR1934 or CR1934.5

  Compared mappings for CR1934, 1934.5, 1935

  Streamers 4&5 (CR1934 features) map to same AR as in CR1935

  - confirms this source regions mapping

  Streamer 1 (CR1934.5 feature) maps to same AR in 1934.5 and1935

  Maps to NCH in CR1934 -- but feature is near data discontinuity (~360°)

Sensitivity of Mappings to Errors

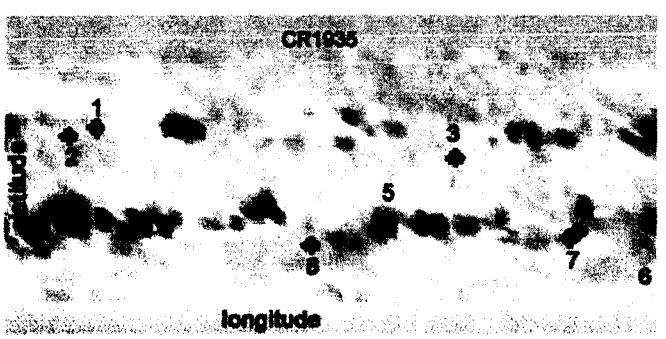
How sensitive is photospheric source determination to errors in location at source surface?

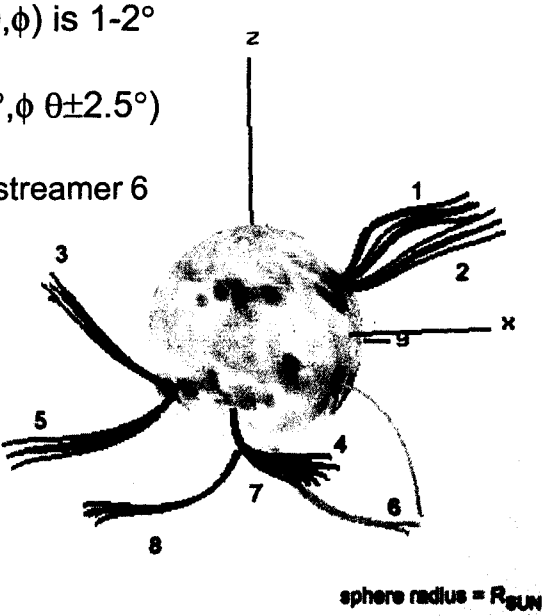
- Typical error in streamer location at SS (θ,ϕ) is 1-2°

- Here, show traces for field lines at ($\theta\pm2.5°,\phi\ \theta\pm2.5°$)

  Error at solar surface is smaller

  No mappings changed except "uncertain" streamer 6

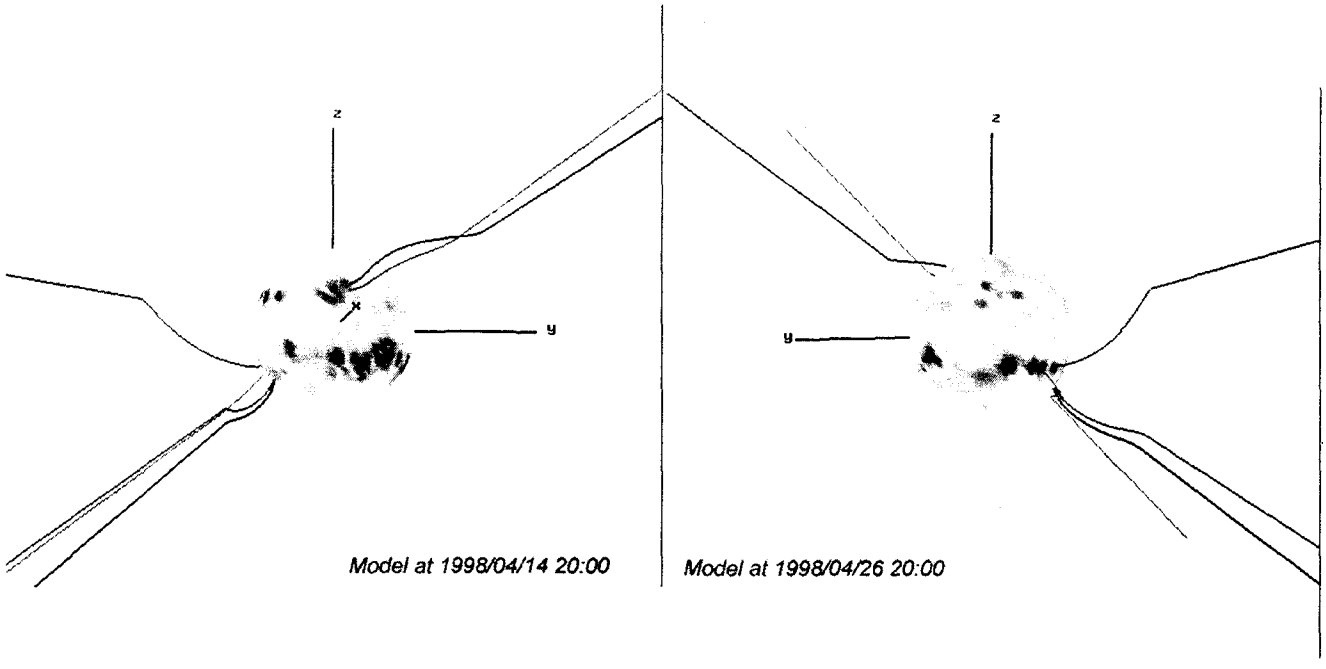




Created Coronal Streamer Model

Assume Streamers coincide with magnetic field lines

6 AR streamers are radial to source surface ($2.5R_S$) connected to traced field lines from source surface to solar surface

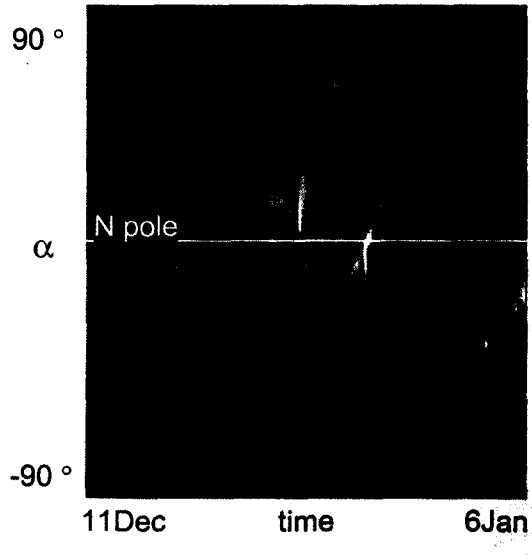


Analysis for CR1957--Near Solar Maximum

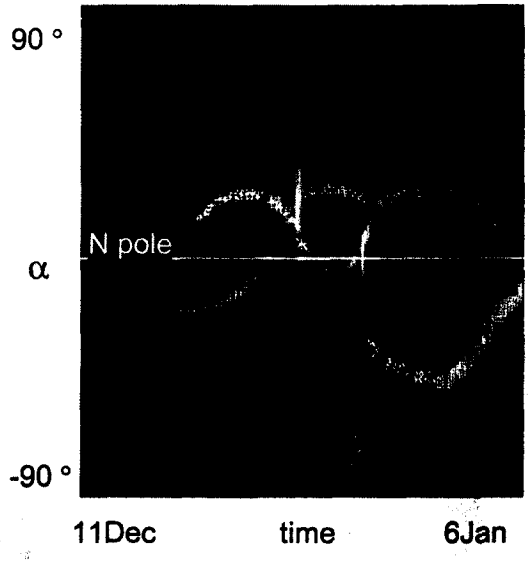
C3 Data every ~6 hr from December 11,1999-January 6, 2000

Preliminary Analysis of 6 North Hemisphere Streamers

North Hemisphere R=8-16 R_{sun}



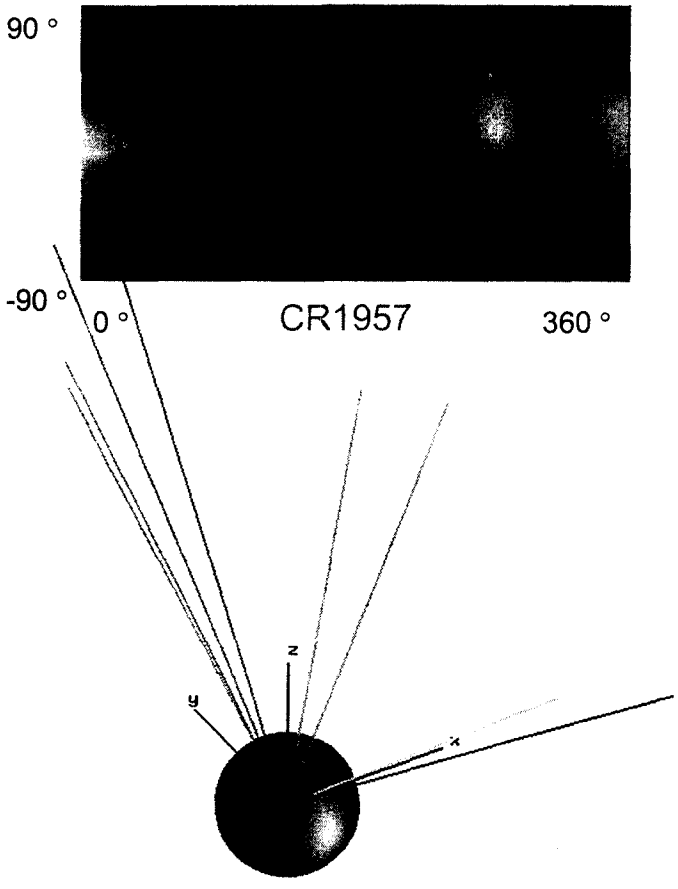
North Hemisphere showing 6 traced features



Note that streamers now cluster around north pole, not equator

Comparison of Data and Model for CR1957

Source Surface Current Sheets and Streamers



CR1957-near solar maximum

Most streamers do not appear to lie on current sheet as computed from source surface model

4 of 6 streamers at latitudes above 60° where magnetogram data is poor

Moreover, current sheet not well defined..large regions of very low field magnitude

Too much uncertainty in magnetogram and source surface model to draw any conclusions

Conclusions

- LASCO Steady (~days-weeks) coronal streamers analyzed

  Used variation in plane-of-sky angle with solar rotation to determine 3D location -- latitude and longitude

  Used potential magnetic field model to find relationship to current sheet and to map streamers from source surface to solar surface

- Results for CR 1935

  All 8 streamers lie near current sheet

  6 streamers map to active regions
  suggests these are true regions of enhanced density

  Active regions are bright when AR and streamer both visible

- Next

  Continue analysis of 1998 Data (Solar Maximum) & analyze WSM3

  Create synthetic coronagraph observations for comparison